CHAPTER 9

Comparisons to Evaluate Water Management Strategies

Kenneth C. Tarboton[1] and Michelle M. Irizarry-Ortiz[1]

Introduction

In this section, tools (graphics and tables) that can be used to compare habitat suitability indices in the evaluation of water management alternatives are demonstrated. In the results section of the preceding chapters (3 though 8), the natural, current, and restored systems as simulated using the Natural System Model version 4.5 and the South Florida Water Management Model version 3.5 were compared for each individual suitability index. This chapter discusses how suitability indices can be used to show trade-offs between ecological indicators in comparing alternative water management strategies. These types of comparison can be very useful in highlighting areas and instances where a water management action that is designed to achieve some degree of restoration (improving the quantity, quality, timing and distribution of water) may improve some ecological indicators while impacting others. Comparison between indices allows for review of water management strategies and also adds to understanding the relationship between habitat suitability indicators allowing for their refinement as appropriate.

Long-term habitat suitability, which is a function of hydrologic conditions over the model simulation period of record, was presented for the landscape-scale suitability functions: ridge and slough landscape, periphyton, and tree islands. Time-varying indices for fish and alligators were developed and averaged over the period of simulation to produce overall spatially-variable suitability. For tree islands, two habitat suitability indices were developed that proved to be most useful: tree island species richness index, which is a period-of-record spatially-varied value, and tree island suitability index, which is a time varying index. For wading birds, time varying indices were produced for each of three zones: the remnant Everglades and the interior and coastal zones of the remnant Everglades.

Overall spatial comparisons between indices are presented first (i.e., comparison of average or long-term suitability for each location or model grid cell), followed by temporal comparisons between indices for a particular spatial location (e.g., a sample indicator region as in **Figure 9-2**). Then a way of comparing temporally-averaged and period-of-record indices by spatial location is presented. Finally, two scenarios are used

1. South Florida Water Management District

(with the same sample indicator region) to show how suitability indices can be used to evaluate the effect on habitat suitability of different water management strategies.

Spatial Comparisons

Comparison of the long-term or period-of-simulation average suitability indices for the ridge and slough landscape, tree island species richness, periphyton, fish, and alligators is presented in **Figure 9-1** for the simulated restored system. The graphic for each individual habitat was presented previously when comparisons between alternatives were made for each index, however examination of suitability in space across indices for the same alternative allows for interesting comparisons of suitability patterns between indices or habitats.

Examination of **Figure 9-1** reveals several key areas of trade-offs between habitat suitability as follows:

- Shark River Slough appears highly suitable for fish and alligators, is relatively less suitable for ridge and slough and tree islands, and has poor suitability for periphyton.
- The marl prairie areas (see Ochopee Marl Marsh and Rockland Marl Marsh on **Figure 3-1**) on the edges of Shark River Slough are well suited to periphyton production but less suitable for alligators. They fall outside the domain of the ridge and slough, tree island and fish suitability indices.
- Water Conservation Area (WCA) 3B has low suitability for the ridge and slough landscape and periphyton production, relatively better suitability for alligators and tree islands, and high suitability for fish.
- The area of highest ridge and slough suitability is in WCA 3A northwest of the L-67 canal and south of Alligator Alley. This area is also highly suitable for fish and periphyton, however, it is less suitable for alligators and hydrology in this area will likely impact tree island species richness particularly north of the Miami Canal.
- WCA 2A is highly suitable for periphyton and fish while it has moderate suitability for alligators and low suitability for the ridge and slough landscape and tree islands.
- The Arthur R. Marshall Loxahatchee National Wildlife Refuge (LNWR) has high fish and tree island species richness suitability (except in the south), moderate suitability for alligators, and poor suitability for periphyton and the ridge and slough landscape.

Similar graphics and analysis could be produced for the natural and current system. The point is, that by comparing spatial habitat suitability between indices, areas can be identified where the hydrology of a particular water management strategy (e.g., the current or restored system) makes habitat more suitable for one habitat while making it

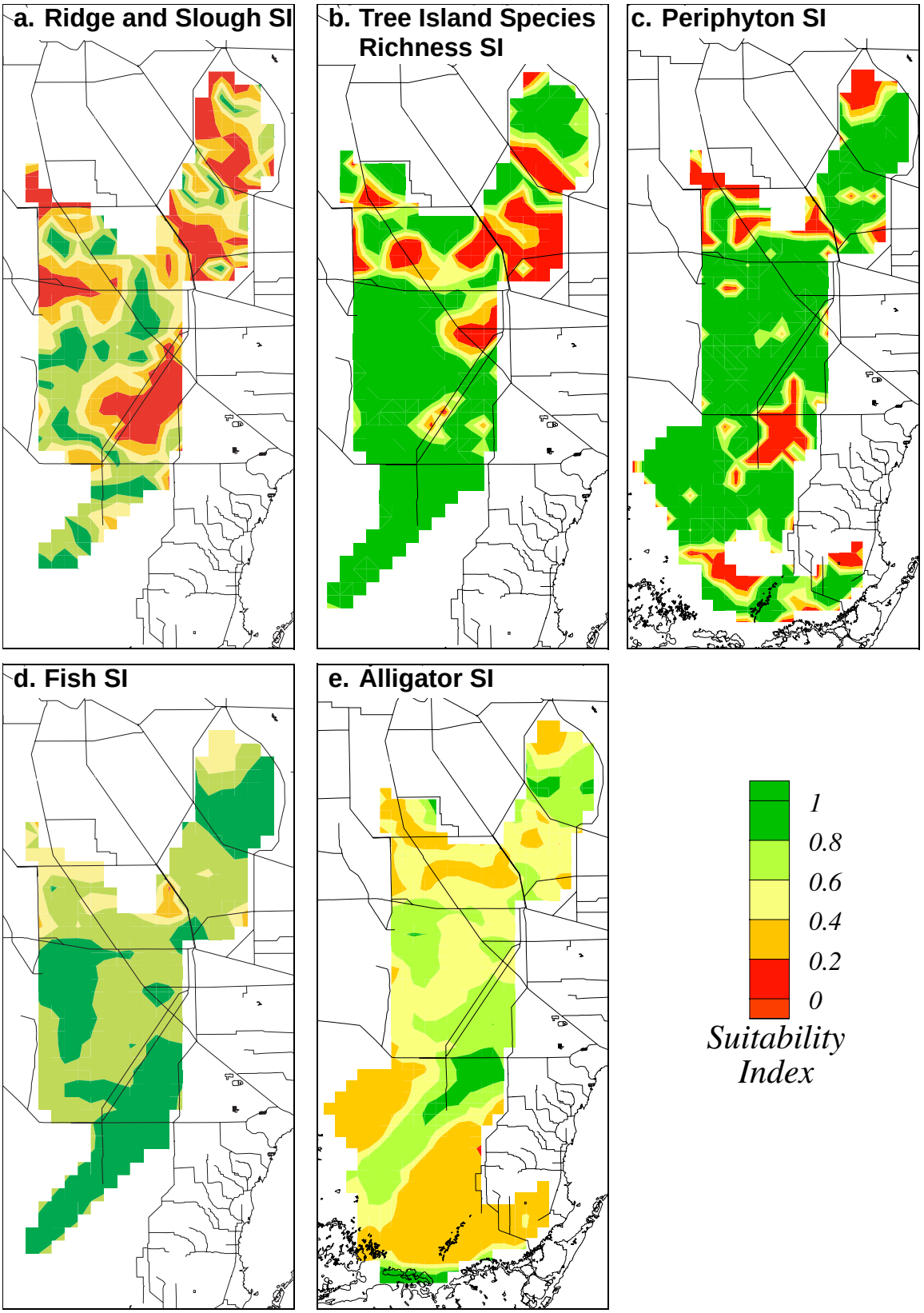

Figure 9-1. Comparison of simulated restored system habitat suitability indices (SIs) for a. ridge and slough landscape, b. tree island species richness, c. periphyton, d. fish, and e. alligators.

less suitable for another habitat. When examined in this way, spatial comparisons between habitat suitability indices can provide very useful information.

The overall spatial average suitability index could have been determined for each habitat, but this provides very little additional information. Overall average index values would likely be very similar and would mask the different, and sometimes contrasting, levels of suitability in different areas. An overall average would not tell us, for example, that for the restored system, the simulated hydrology results in poor suitability for ridge and slough in the same area (LNWR) that there is high suitability for tree islands.

The usefulness of habitat suitability indices is that they can identify areas where trade-offs may occur. In some cases these trade-offs may be valid. For example, restoration goals might seek to maintain tree island species richness in LNWR at the expense of not restoring the ridge and slough landscape in this area. However, in other cases, the indices may point to areas of concern that require further investigation using more complex individual species models or revisiting features of the particular management strategy that cause the trade-off to occur.

Temporal Comparisons

Temporal comparisons can be made at specific locations (normally indicator regions) to give an indication of when trade-offs between habitat suitability occur due to changing hydrologic conditions. Shark River Slough Indicator Region 129 (**Figure 9-2**) is used as an sample indicator region for temporal comparisons. In **Figure 9-3**, fish, alligator, and the tree island habitat suitability (not tree island species richness) are compared for the Shark River Slough indicator region for the natural system simulation. Fish suitability in this indicator region is fairly insensitive to hydrologic change; it remains above a value of 0.8 for most years and has a mean value of 0.92 for the period of simulation (1965 to 1995). Alligator suitability fluctuates more with hydrologic change; it ranges from values below 0.4 to values close to 1.0 and has a mean value of 0.76 for the period of simulation. Tree island suitability is very sensitive to hydrologic change; it ranges from 0.0 to 1.0 with a mean value of 0.19 for the period of simulation. The temporal pattern of suitability for fish and alligators is fairly consistent, while there is a trade-off or inverse relationship between alligator and tree island suitability in this indicator region. In relatively dry years, particularly 1981 and 1990, tree island suitability is high because the risk of flooding is reduced. In these same years, shallower depths reduce alligator suitability. A deviation from this pattern is 1978 when tree island suitability is high while alligator suitability also remains high. In this case, the timing of dry out that reduced the risk of flooding for tree islands was such that it did not impact alligator suitability.

Suitability indices can be combined for a particular alternative at a specific location (normally an indicator region). The fish, alligator, and tree island suitability indices, presented in **Figure 9-3** for the natural system were combined in **Figure 9-4** to produce a mean combined suitability index for the natural system for the Shark River Slough indicator region. A similar process was used to produce combined suitability

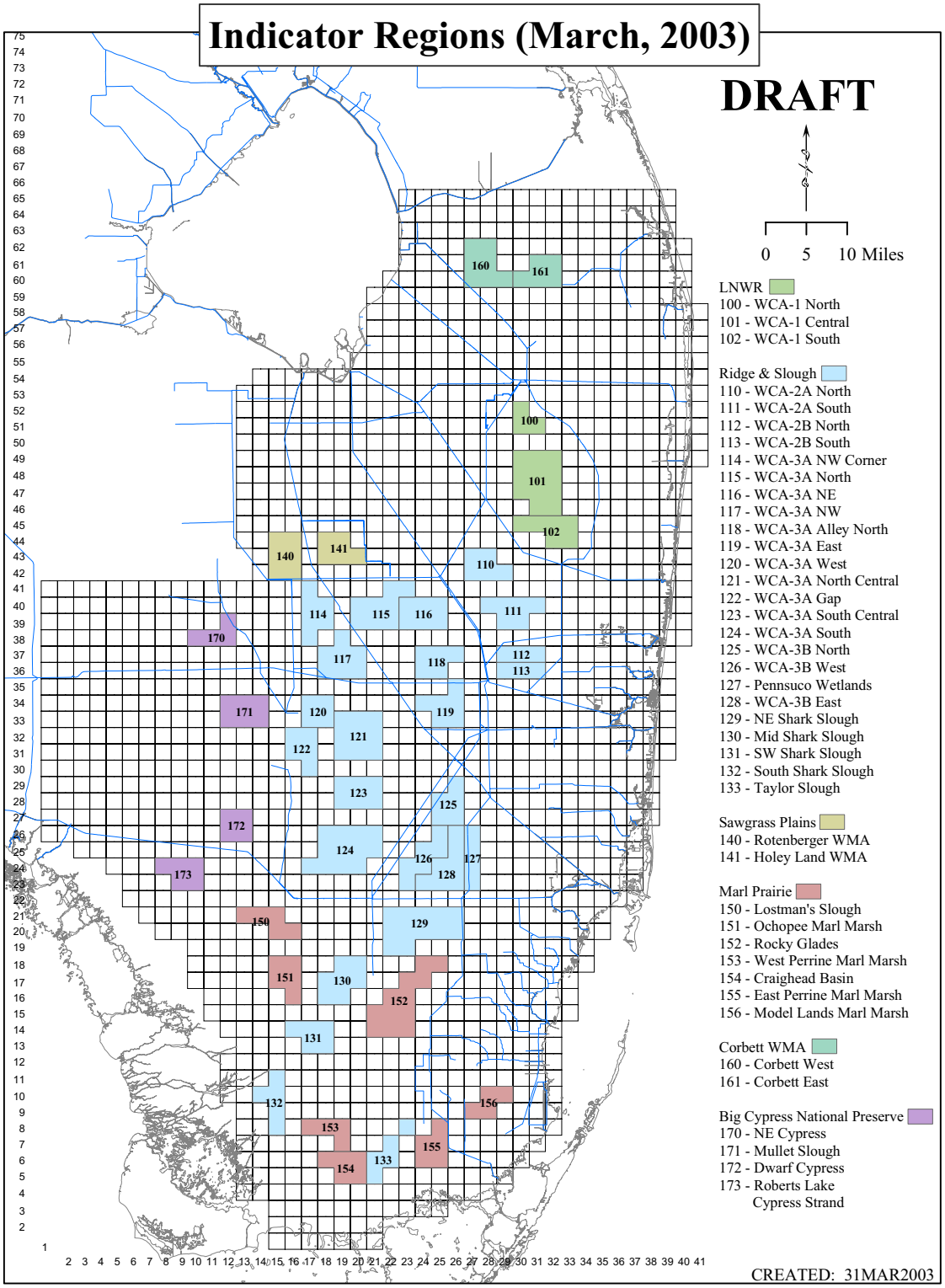

Figure 9-2. Indicator region map, color-coded by landscape type.

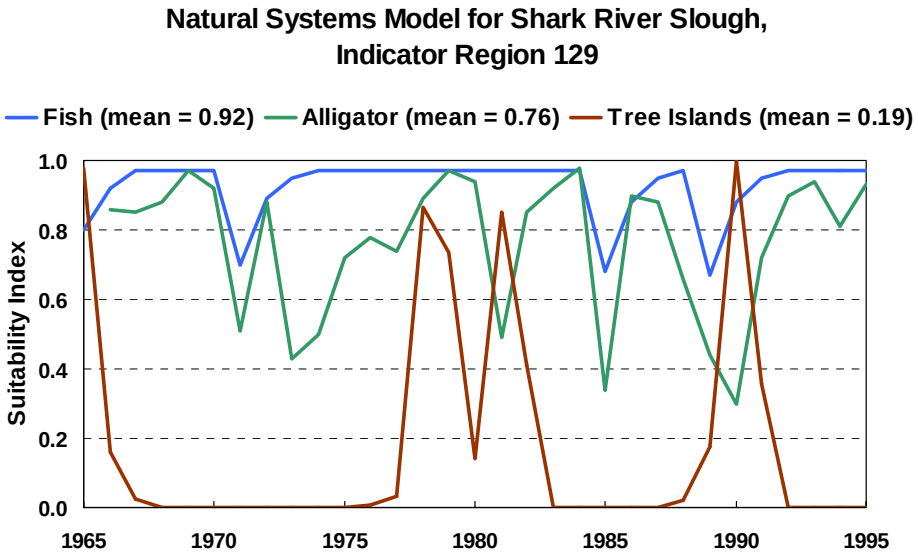

Figure 9-3. Comparison of fish, alligator and tree island habitat suitability in Shark River Slough Indicator Region 129 for the natural system.

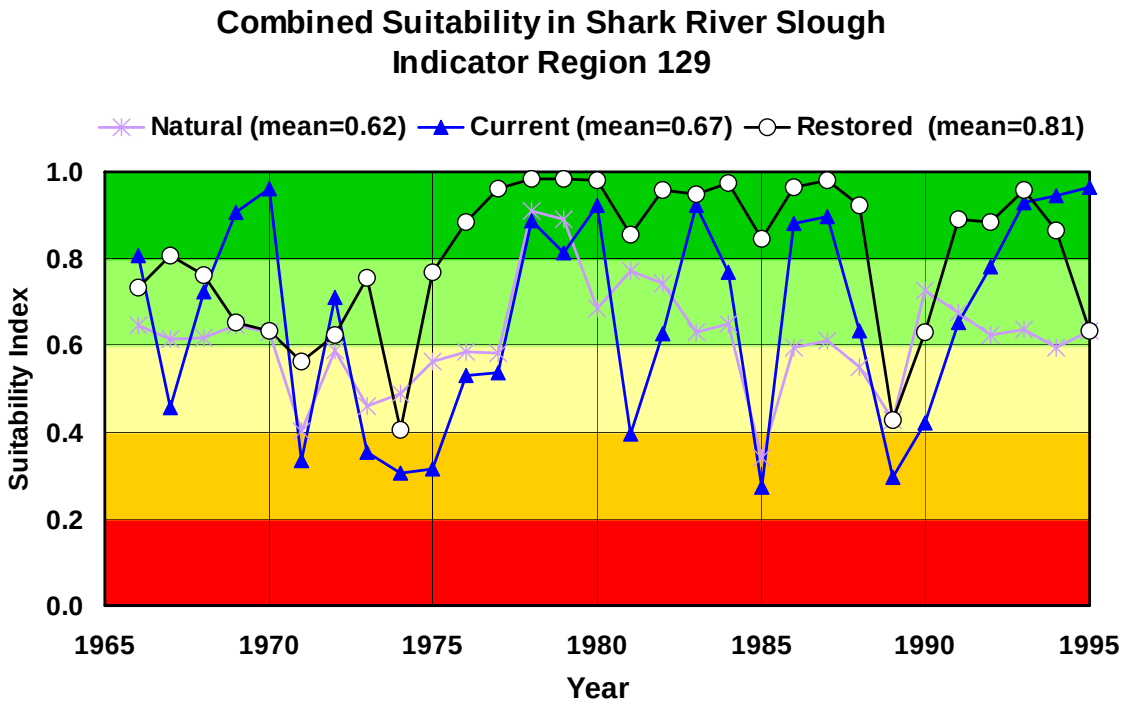

Figure 9-4. Comparison of combined (fish + alligator + tree island) suitability indices for the natural, current, and restored systems in Shark River Slough Indicator Region 129.

indices for the current, and restored systems. Combination of multiple or selected indices could involve any desired weighting scheme to reflect the relative importance of the habitat or objectives of the project. In this case, an equal weighting was given to each of the indices. Comparison and interpretation of combined habitat suitability indices is not as clear as comparison and interpretation of individual indices. Combination results in a degree of loss of information. In this case, it can be said that the restored system has higher combined habitat suitability for most years and an overall higher mean suitability (0.81) than the current system (mean = 0.67) and the natural system (mean = 0.62). In some instances, combination of indices can provide useful information to answer specific questions.

Temporal comparisons for the entire landscape are not discussed because the averaging of a range of suitability from different parts of the landscape into a single number would render these comparisons relatively meaningless.

Average Temporal and Spatial Comparison

Averaging temporally-variable suitability indices (e.g., tree island suitability index, small fish, and alligator in **Figure 2-1**) for specific indicator regions over the period of record is appropriate and provides meaningful information. In the example given in **Figure 9-3**, the Shark Slough indicator region is better suited to fish habitat (mean = 0.92) than alligators (mean = 0.76) and has low suitability for tree islands (mean = 0.19).

Temporally-averaged suitability indices (e.g., tree island species richness index, ridge and slough, and periphyton in **Figure 2-1**) for indicator regions can be compared with indices averaged over the period of record for the same indicator regions, permitting wider comparison of habitat suitability by indicator region. Furthermore, mean or period-of-record suitability values for each indicator region (**Figure 9-2**) can be combined into landscape-type average suitability values. An example of this type of comparison is shown in **Table 9-1** for the current (95BSR) and restored (D13R) systems. Values in **Table 9-1** are used to depict the type of comparisons that could be made with this table. Suitability values could be compared between alternatives and between habitats horizontally across the table for each indicator region. The table uses period-of-record values for the ridge and slough landscape, tree island species richness, and periphyton, while using average values for the simulation period (equal to the period of record) for fish and alligators.

Habitat suitability between indicator regions could be compared vertically down the columns of **Table 9-1**. The shaded rows indicate landscape-type average suitability, i.e., the average suitability for a particular landscape. This allows for comparisons of habitat suitability between alternatives within a landscape type and also comparison of habitat suitability between landscape types.

Table 9-1. Comparison of habitat suitability indices by indicator region and for landscape types comprising several indicator regions as defined in **Figure 9-2**. Suitability increases with increasing index value from 0 to 1.

Indicator Number and Name		# Cells	Ridge and Slough		Tree Islands		Periphyton		Fish		Alligators	
			95BSR	D13R	95BSR	D13R	95BSR	D13R	95BSR	D13R	95BSR	D13R
100	WCA 1 North	3	0.10	0.04	0.67	0.67	0.03	0.03	0.50	0.49	0.25	0.25
101	WCA 1 Central	11	0.25	0.26	0.98	1.00	0.77	0.72	0.80	0.78	0.66	0.64
102	WCA 1 South	6	0.19	0.27	0.44	0.50	1.00	0.99	0.92	0.89	0.78	0.76
LNWR Indicator Region Average[a]			0.21	0.23	0.77	0.80	0.73	0.70	0.79	0.77	0.63	0.62
110	WCA 2A North	5	0.24	0.31	0.39	0.61	0.82	0.98	0.65	0.70	0.45	0.49
111	WCA 2A South	6	0.51	0.37	0.90	0.59	1.00	1.00	0.72	0.72	0.48	0.52
112	WCA 2B North	3	0.48	0.68	0.39	0.38	0.95	0.68	0.71	0.67	0.58	0.49
113	WCA 2B South	3	0.19	0.22	0.00	0.00	1.00	0.88	0.75	0.73	0.60	0.58
114	WCA 3A Northwest Corner	6	0.40	0.53	0.00	1.00	0.04	0.92	0.52	0.71	0.22	0.51
115	WCA 3A North	5	0.31	0.54	0.00	0.40	0.15	0.61	0.54	0.62	0.27	0.40
116	WCA 3A Northeast	5	NA[b]	NA	0.12	0.88	NA	NA	NA	NA	0.26	0.38
117	WCA 3A Northwest	7	0.52	0.46	0.53	0.69	0.65	0.67	0.64	0.71	0.42	0.50
118	WCA 3A Alley North	5	0.57	0.73	0.74	0.81	1.00	0.93	0.78	0.70	0.66	0.48
119	WCA 3A East	6	0.42	0.87	0.00	0.78	0.91	1.00	0.90	0.78	0.71	0.59
120	WCA 3A West	4	0.60	0.52	0.57	1.00	1.00	0.74	0.67	0.86	0.46	0.76
121	WCA 3A North Central	9	0.74	0.64	1.00	0.94	1.00	0.90	0.75	0.82	0.55	0.63
122	WCA 3A Gap	5	0.54	0.54	1.00	0.83	0.38	0.96	0.63	0.80	0.38	0.59
123	WCA 3A South Central	6	0.65	0.71	1.00	0.97	1.00	0.89	0.79	0.77	0.64	0.54
124	WCA 3A South	12	0.56	0.76	0.08	1.00	0.47	1.00	0.89	0.79	0.72	0.59
125	WCA 3B North	5	0.56	0.23	0.13	0.08	1.00	1.00	0.80	0.81	0.69	0.67
126	WCA 3B West	6	0.30	0.42	0.97	1.00	1.00	0.61	0.81	0.91	0.68	0.76
127	Pennsuco Wetlands	4	0.00	0.09	0.05	0.80	0.01	0.82	0.56	0.78	0.48	0.68
128	WCA 3B East	7	0.16	0.42	0.66	0.93	0.96	0.68	0.71	0.90	0.60	0.78
129	Northeast Shark River Slough	12	0.12	0.64	0.69	0.88	0.83	0.23	0.70	0.93	0.53	0.83
130	Mid-Shark River Slough	7	0.74	0.77	1.00	0.99	1.00	0.51	0.75	0.92	0.57	0.80
131	Southwest Shark River Slough	5	NA	NA	0.26	1.00	0.93	1.00	0.66	0.81	0.46	0.68
132	South Shark River Slough	5	NA	NA	NA	NA	NA	NA	NA	NA	0.44	0.62
133	Taylor Slough	5	NA	NA	NA	NA	1.00	0.99	NA	NA	0.27	0.26
Ridge and Slough Indicator Region Average			0.44	0.55	0.51	0.80	0.77	0.79	0.72	0.80	0.52	0.61

a. Landscape-average habitat suitability index is calculated by weighting the habitat suitability index for each indicator region within the landscape type by the number of cells in the indicator region. Only applicable indicator regions (without NA) are averaged to obtain landscape-average habitat suitability index.

b. NA means the indicator region is not completely within the applicable grid for the habitat suitability index.

Scenario Comparisons

Habitat suitability indices are useful when evaluating different management scenarios to see how a particular scenario might affect ecology in particular areas. The preceding chapters (3 through 8), already have considerable discussion of differences between the natural, current, and restored system for each suitability index. Suitability indices can also be used to look at the specific effect of a management scenario on a particular performance measure. Two scenarios based in the restored system were simulated to illustrate this approach. In scenario 1, all aquifer storage and recovery features (with a pumping capacity of 5,000 acre-feet per day) were removed from the restored system. These features were located predominantly around Lake Okeechobee, in the Caloosahatchee basin, and in the Lower East Coast developed area. In scenario 2, storage capacity in the in-ground storage (280,000 acre-feet) north and south of Miami Canal in the Lower East Coast developed area was removed from the restored system. Following the example above, the effect of these two scenarios on Shark River Slough Indicator Region 129 was investigated for alligator habitat suitability.

A probability exceedance function for alligator suitability, shown in **Figure 9-5** indicates that for this particular region, the removal of aquifer storage and recovery features has negligible effect on alligator suitability. At the same time, a considerable reduction in alligator suitability is caused by removing the in-ground storage areas. The probability of alligator suitability in Indicator Region 129 exceeding a value of 0.8 is reduced from around 75 percent to around 40 percent when in-ground storage is removed. The mean (50 percent probability) alligator suitability is reduced from a value of 0.81 for the restored system to a value of 0.64 with the in-ground storage areas removed.

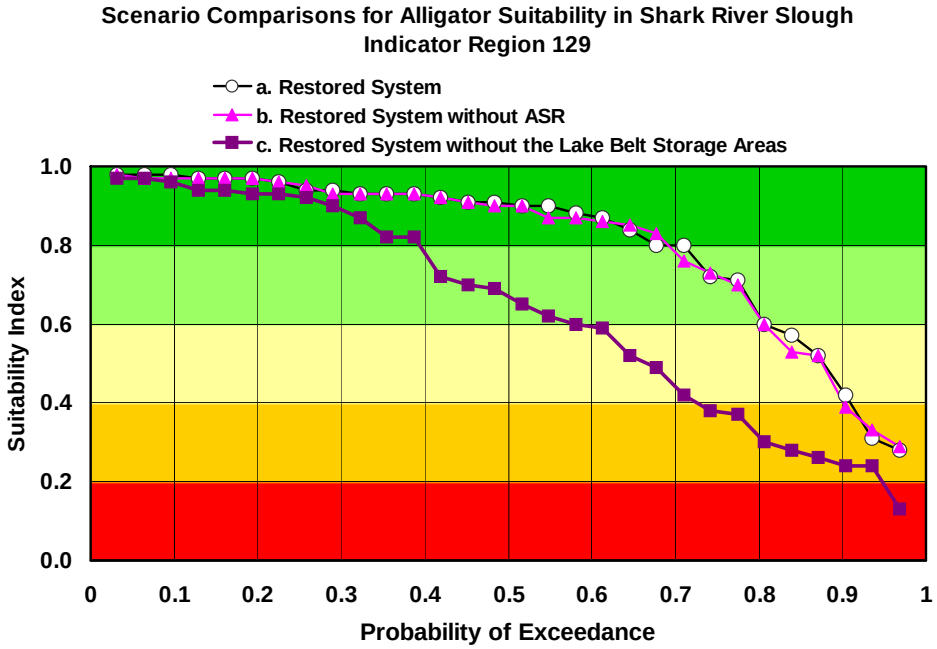

Figure 9-5. Probability exceedance function for alligator suitability in Shark River Slough Indicator Region 129, for the a. restored system, b. restored system without aquifer storage and recovery (ASR), and c. restored system without the Lake Belt storage areas.

Summary

Spatial comparisons can highlight areas where trade-offs between habitat suitability functions occur in different simulated water management alternatives. These trade-offs can be further investigated using more complex models if necessary. Temporal comparisons provide a means of seeing the year-to-year trade-offs between habitat suitability and the sensitivity of individual suitability functions to hydrologic change. Temporal averaging for specific locations (indicator regions) or even landscape types can provide useful information for comparison purposes and permits comparison between period-of-record suitability indices and temporally-averaged (over the simulation period) suitability indices. Comparison of habitat suitability at particular locations for different water management strategies or scenarios can reveal information about the effects of these strategies at those locations. Indicator regions can be used to highlight particular management strategies that cause habitat suitability impacts and the location (indicator region) in which the impacts occur. This allows for refinement of the management features causing habitat suitability impacts, further investigation, or refinement of the suitability indices if necessary.